Heavy Ion Response of Amorphous Silicon Transmission Detectors for Particle Identification

M. Amman, L. Beaulieu†, W. S. Hong*, L. Phair†, J. T. Walton*, and G. J. Wozniak†*

To overcome the problems inherent in the discrete silicon ΔE detectors of ΔE–E particle identification telescopes, integrated designs in which the ΔE detector is fabricated directly on top of the E detector have been investigated by others. Such an approach potentially allows for the fabrication of a uniformly thin ΔE detector that has the ruggedness of the underlying E detector. In an effort to determine the applicability of hydrogenated amorphous silicon (a-Si:H) transmission detectors to an improved integrated ΔE–E telescope design, we have measured the response of discrete a-Si:H detectors to ions with atomic numbers between 7 and 36 and ranging in energy from 0.5 to 4.5 MeV / nucleon [1].

Measured pulse height spectra show substantial pulse height deficits which depend on detector bias. This behavior can be understood based on the small charge carrier mobility-lifetime products of a-Si:H and collection field screening caused by the large ionization density left by the heavy ion.

A more unexpected result obtained is that the amplitudes of the detector pulses correlate better with the total ion energy than with the ion energy deposited in the transmission detector. This is illustrated in Fig. 1. A possible explanation for this response is that little of the collected charge comes from the central region of the ionization track as a result of the dense ionization leading to collection field screening. The collected charge is primarily that scattered outside the central ionization track. These charge carriers can be generated by energetic electrons scattered outside the central track by the ion. The maximum energy of these scattered electrons is proportional to the total ion energy, thus giving rise to a detector signal that is dependent on the ion energy.

Our measurements have both helped to elucidate the complex charge transport mechanisms in a-Si:H and demonstrated that our a-Si:H diodes do not function as ΔE detectors, thus making them inappropriate for the integrated telescope application.

Footnotes and References

* Engineering Division

† Nuclear Science Division

[1] M. Amman *et al.*, *IEEE Trans. Nucl. Sci.*, accepted for publication.

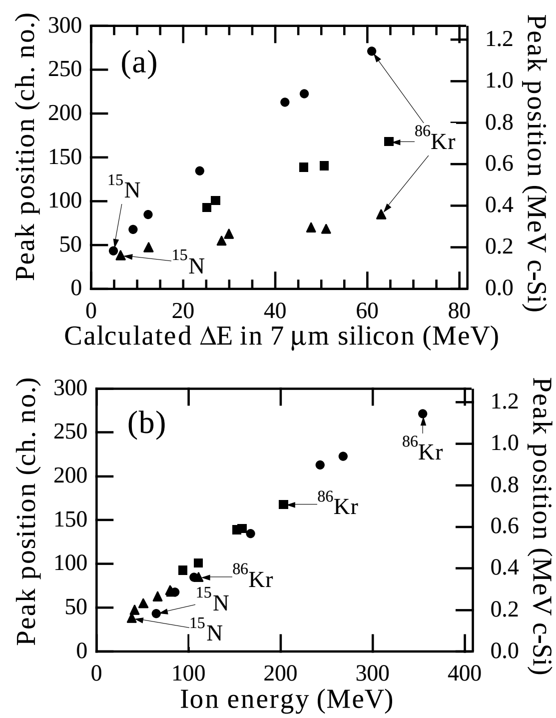

Fig. 1. (a) Ion peak positions measured with a 7 μm thick a-Si:H detector plotted as a function of the calculated energy deposited in the intrinsic layer of the detector. The peak positions were measured for 4.5 MeV / nucleon ions (circles) and for ions of this energy degraded by 5 μm (squares) and 7.5 μm thick (triangles) Ta foils. (b) The ion peak positions of (a) plotted as a function of the total energy of the ions as they pass through the detector.